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DESIGN AND TESTING OF A PYROGEN IGNITER FOR A LO_2 - LH_2 ROCKET ENGINE

TECHNICAL DOCUMENTARY REPORT NO. SSD-TDR-62-201

DECEMBER 1962

6593d TEST GROUP (DEVELOPMENT)
EDWARDS, CALIFORNIA

HEADQUARTERS
SPACE SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

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Authors

Harold W. Gale, 1/Lt, USAF
Philip C. Moedt, 1/Lt, USAF

This report has been reviewed and approved.

HAROLD W. NORTON
Colonel, USAF
Commander

6593d Test Group (Development)
Edwards, California
Space Systems Division
Air Force Systems Command
United States Air Force

FOREWORD

This technical report has been prepared to present the design and test results, of a solid propellant pyrogen igniter for a liquid rocket engine incorporating LO_2-LH_2 propellants and the segmented chamber concept.

ABSTRACT

This technical documentary report presents the development and current status of a solid propellant pyrogen igniter used with the LO_2-LH_2 segmented engine. The objective of this igniter project was to provide the liquid chamber with a long duration (four second), hot flame which would be capable of igniting LO_2-LH_2 under the most difficult propellant mixing conditions. Fourteen (14) checkout igniter firings were made and over sixty (60) integrated system tests have been conducted to date. The results of these tests have shown that the igniter is extremely reliable, very durable, and safe to work with.

TABLE OF CONTENTS

	PAGE
Introduction	1
Approach	1
Igniter Description	1
System Description	2
Test Results	2
Conclusions	3
Table I	3
Figure 1	4
Photograph 1	5
Figure 2	6
Figure 3	7
Figure 4	8
Figure 5	9
Figure 6	10

DESIGN AND TESTING OF A PYROGEN IGNITER FOR A LIQUID ROCKET ENGINE INCORPORATING THE SEGMENTED CHAMBER CONCEPT

INTRODUCTION.

The objective of the igniter project was to develop an igniter which could give a continous stream of flame for about four seconds, while operating into a LO_2-LH_2 segmented engine. The duration of four seconds was desired so that ignition would be assured throughout the early stages of propellant mixing in the liquid engine.

APPROACH.

The basic design parameters for the igniter, Table I, were determined by the liquid rocket system requirements. Final design was based primarily on simplicity, safety, ease of handling, durability, system compatibility and reliability.

IGNITER DESCRIPTION.

The igniter is mounted into the side wall of the segmented LO_2LH_2 engine chamber (Figure 1.). The igniter is a small, end burning solid rocket motor which burns for about four seconds. A drawing of the igniter is shown in Figure 2. The propellant grain is manufactured by curing propellant in a short laminated plastic tube and inhibiting one end. The grain is in cartridge form, which can be easily replaced after each firing. The motor case is 4130 steel with a safety factor of about five, based on 1000 psi chamber pressure. The propellant used has no metal additives. This is to avoid deposition in the small throat and possible contamination of the instrumentation in the main segmented engine. The igniter for the pyrogen igniter is an initiator-pyrocord combination as shown in Figure 3. The pressure tap in the igniter is used to start the complete liquid systems test operation after pyrogen ignition.

SYSTEM DESCRIPTION.

The igniter is mounted on the side of the liquid test chamber as shown in Figure 1, and Photograph 1. Initial checkout firings were done on a simulated liquid chamber, as shown in Photograph 1. The pyrogen hot flame enters through the side of the liquid chamber just below the injector. When the chamber pressure in the pyrogen igniter reaches a pre-set level, 410 psi, a pressure transducer initiates the liquid propellant valves. Ignition of the LO_2-LH_2 mixture is assured by the long flame duration.

TEST RESULTS.

Test firing data were obtained by the use of a Brush recorder, Figure 4, 5, and 6. With the checkout firings both igniter chamber pressure and flame impingement temperatures were obtained, while with the operational system firings only the igniter chamber pressure was taken.

The results of the fourteen (14) checkout test firings gave the Liquid Systems Branch confidence in handling and using the igniter. The propellant grains used in the first ten (10) checkout tests were made at the Rocket Research Laboratories from available JATO's. Even though two minor mishaps did occur (firings three and four) because of faulty grains, the problems of system integration, grain storage, initiator pyrocord fabrication, igniter assembly and count down procedures were quickly solved. Throughout all fourteen (14) tests, the same igniter case was used. Two graphite nozzle inserts in the igniter case and two graphite inserts in the side of the liquid chamber were also used. Igniter flame temperatures impinging on the liquid chamber were about 1500°F. A typical pressure-time trace of these checkout firings is illustrated on Figure 4.

The results of the sixty (60) operational tests to date have shown the igniter to be very successful. One minor problem did occur in test firing number two, when a hang-fire occurred. This did not effect the final test objectives.

The same igniter case used in the checkout tests was used throughout these operational tests and will continue to be used in future tests. The replacement rate of the igniter nozzle insert and chamber insert is currently

one per every eight firings. Some typical pressure-time traces of the igniter chamber and the effect of the operating liquid chamber on it are illustrated in Figures 5 and 6.

CONCLUSIONS.

Test results to date have indicated the igniter is safe, durable, reliable, economical, and easy to use. It will continue to be used throughout the segmented engine program and future liquid rocket programs where very severe requirements for ignition reliability exist.

TABLE I

IGNITER SPECIFICATIONS

Case Material			4130. Steel
Graphite Material			HLM 8 5
Safety Factor			5.0
Propellant Type			Lockheed 6 cpx-83-44-4 (Polysulfide)
Propellant Wt		=	0.823 lbs.
Grain Length		=	2.08 inches
Action Time		=	4.6 seconds
Thrust		=	36.8 lbs.
Thrust Coefficient	C_F	=	1.215
Chamber Pressure	P_c	=	800. psi
Expansion Ratio	Ae/At	=	1.0
Burn Rate		=	0.45 in/sec.
Throat Area	A_T	=	.039 in^2
Throat Diameter	D_T	=	.220 in
Burning Rate Exponent		=	0.38
Specific Impulse	Isp	=	205. sec.
Ratio of Specific Heats C_P/C_V		=	1.23
Propellant Density		=	0.062 lbs/in^3

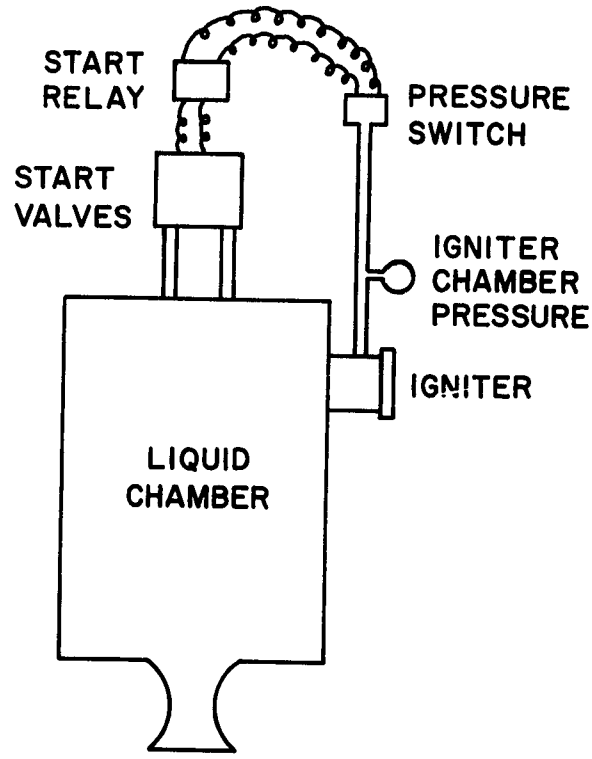
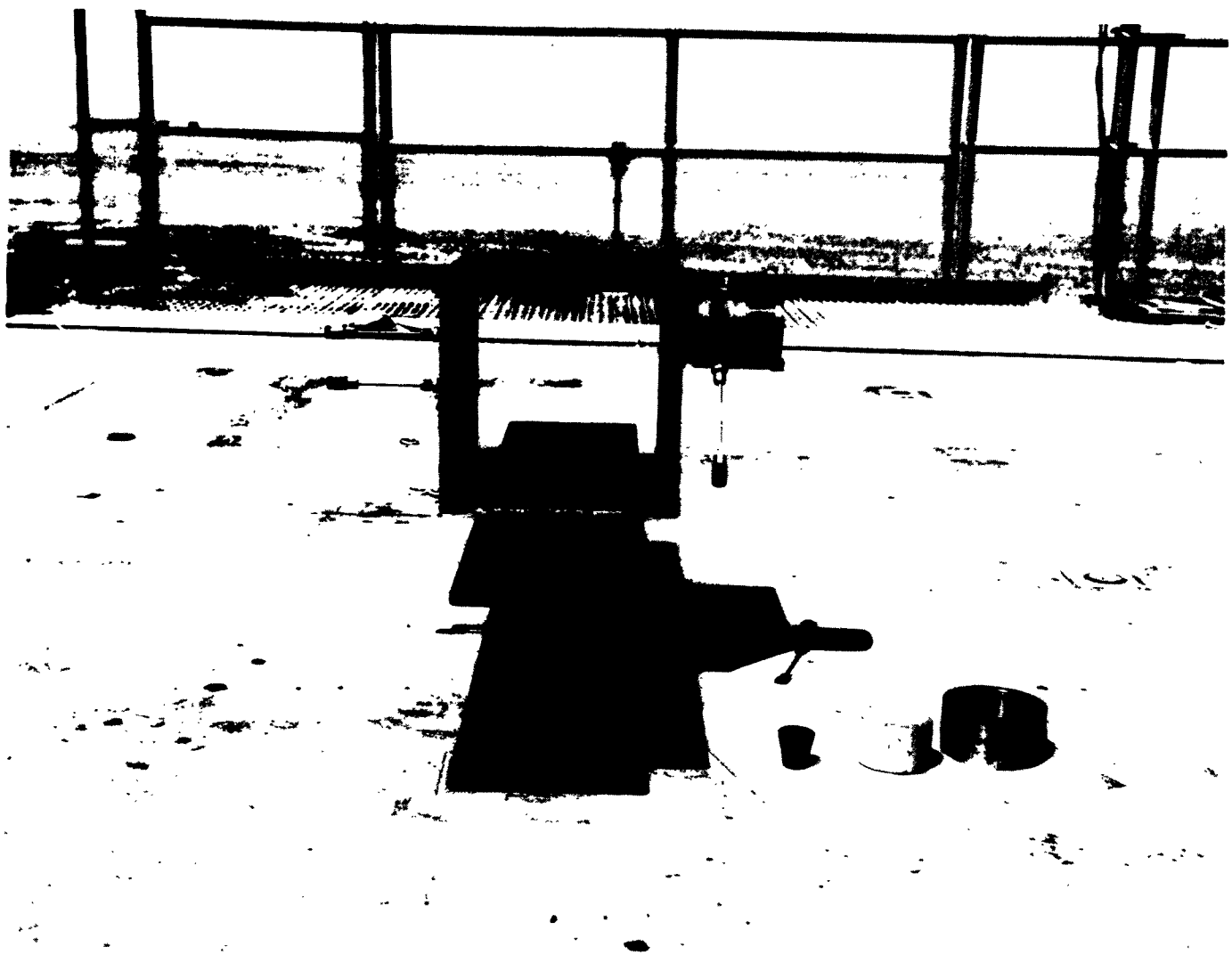


Figure 1. System Diagram



Photograph 1.

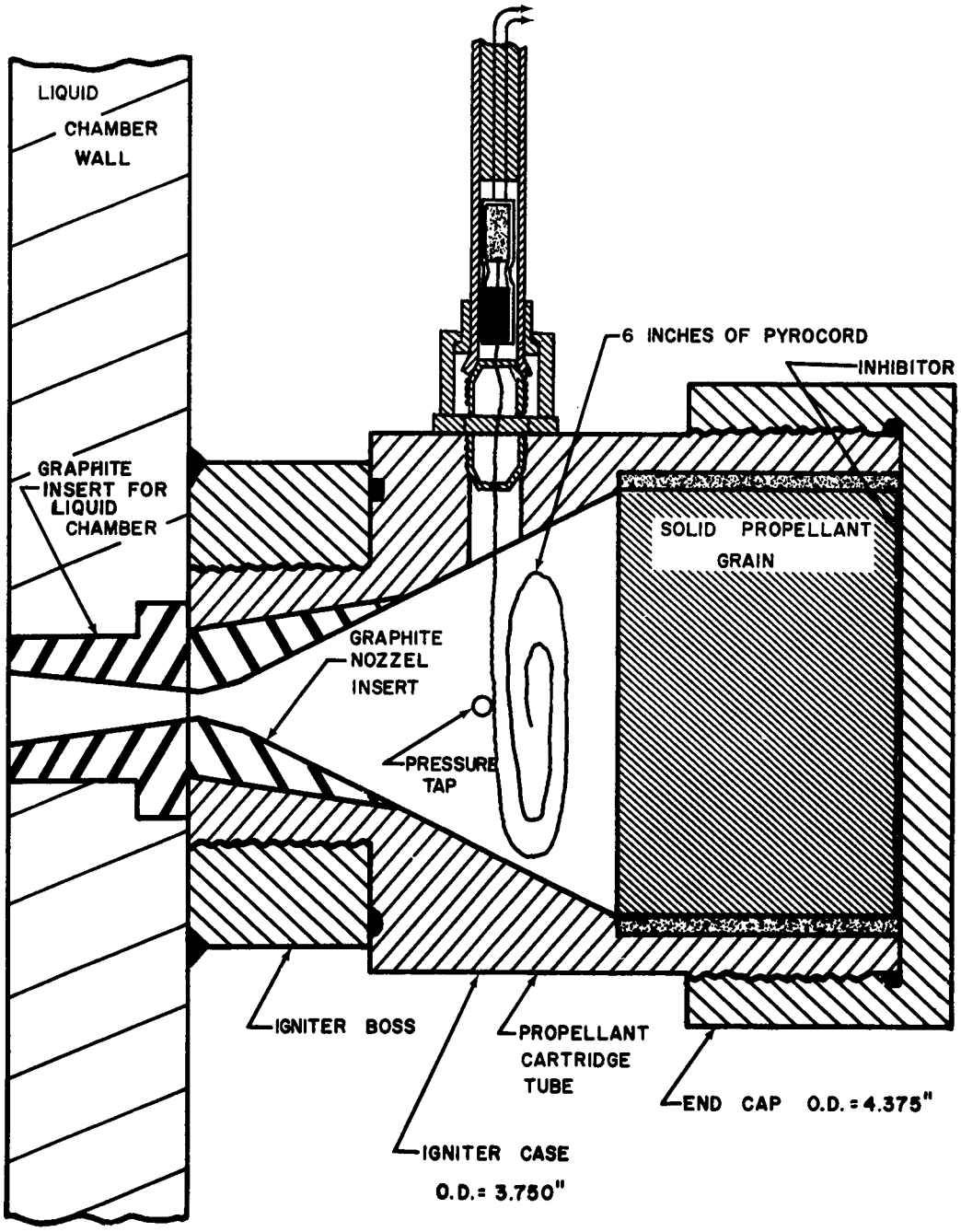


Figure 2. Pyrogen System Assembly

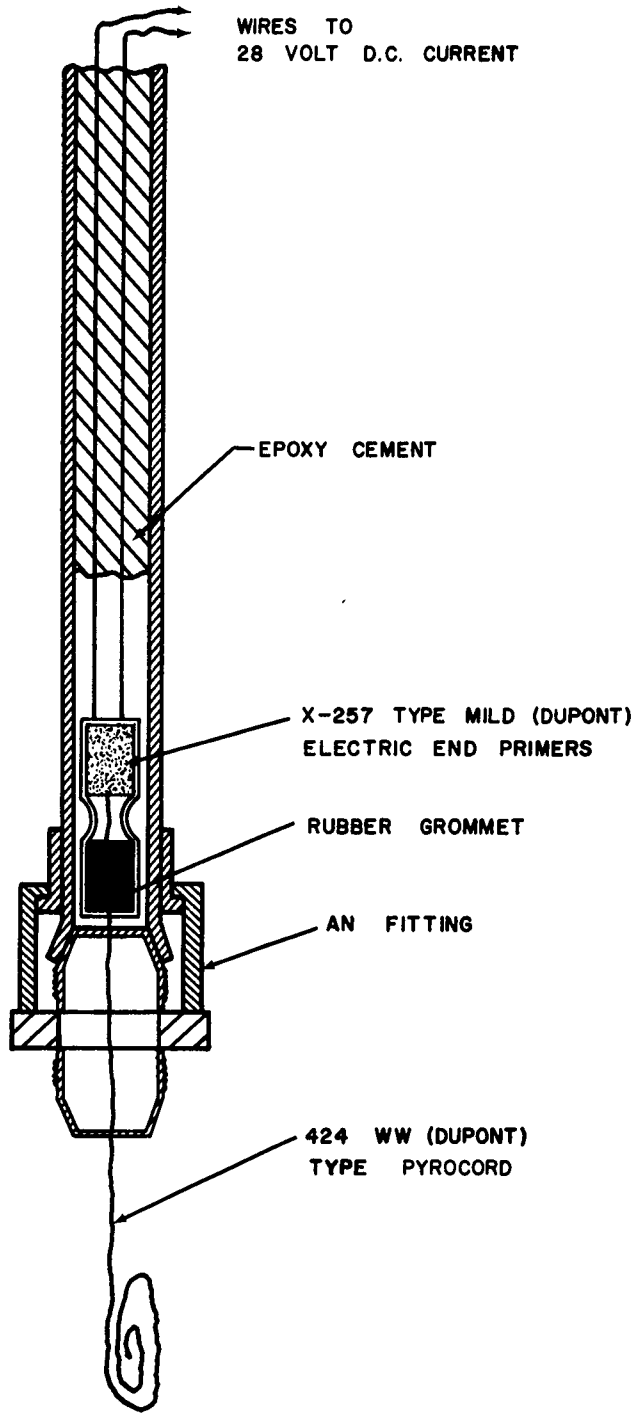


Figure 3. Igniter for Pyrogen

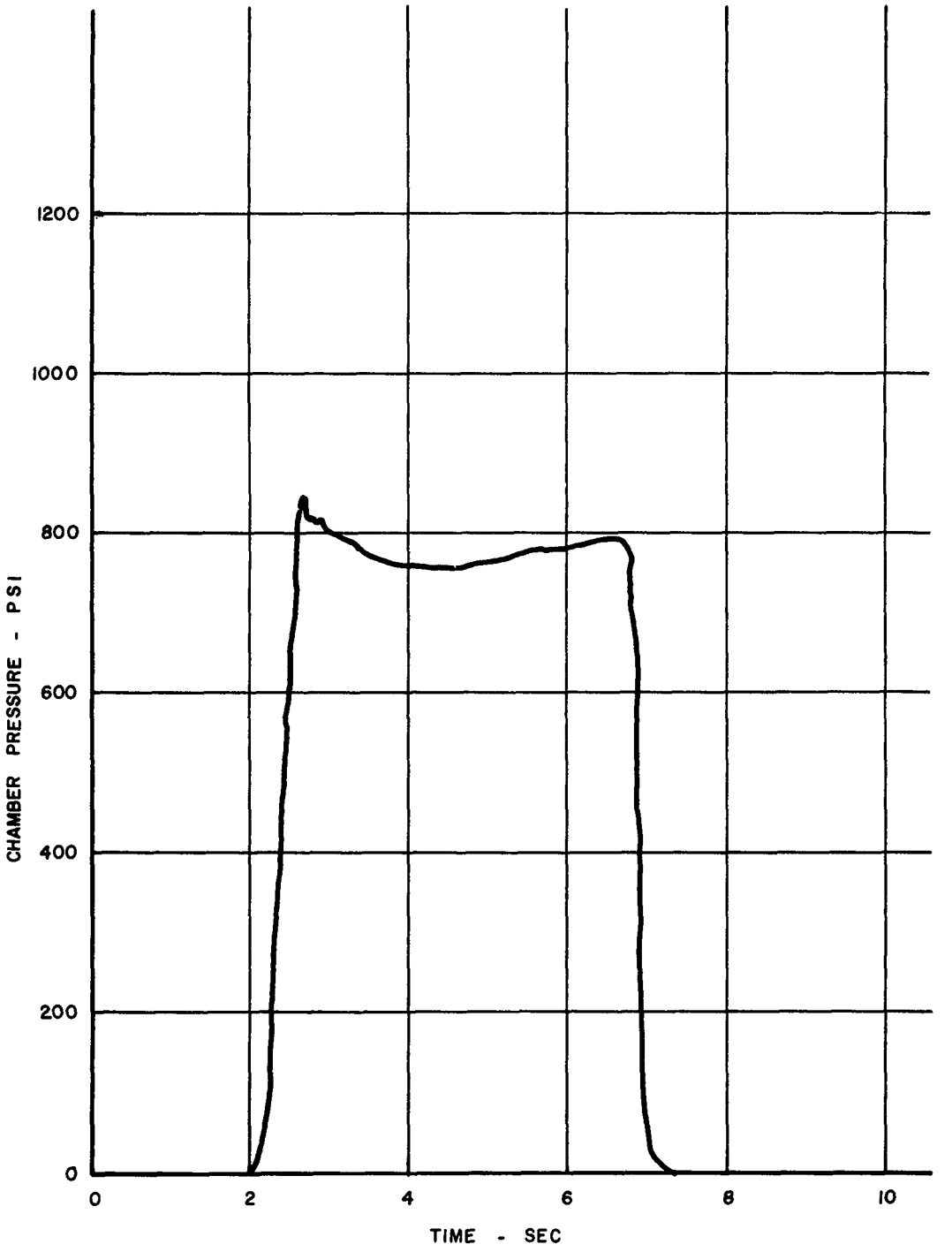


Figure 4. Igniter Test - 7 November 1962

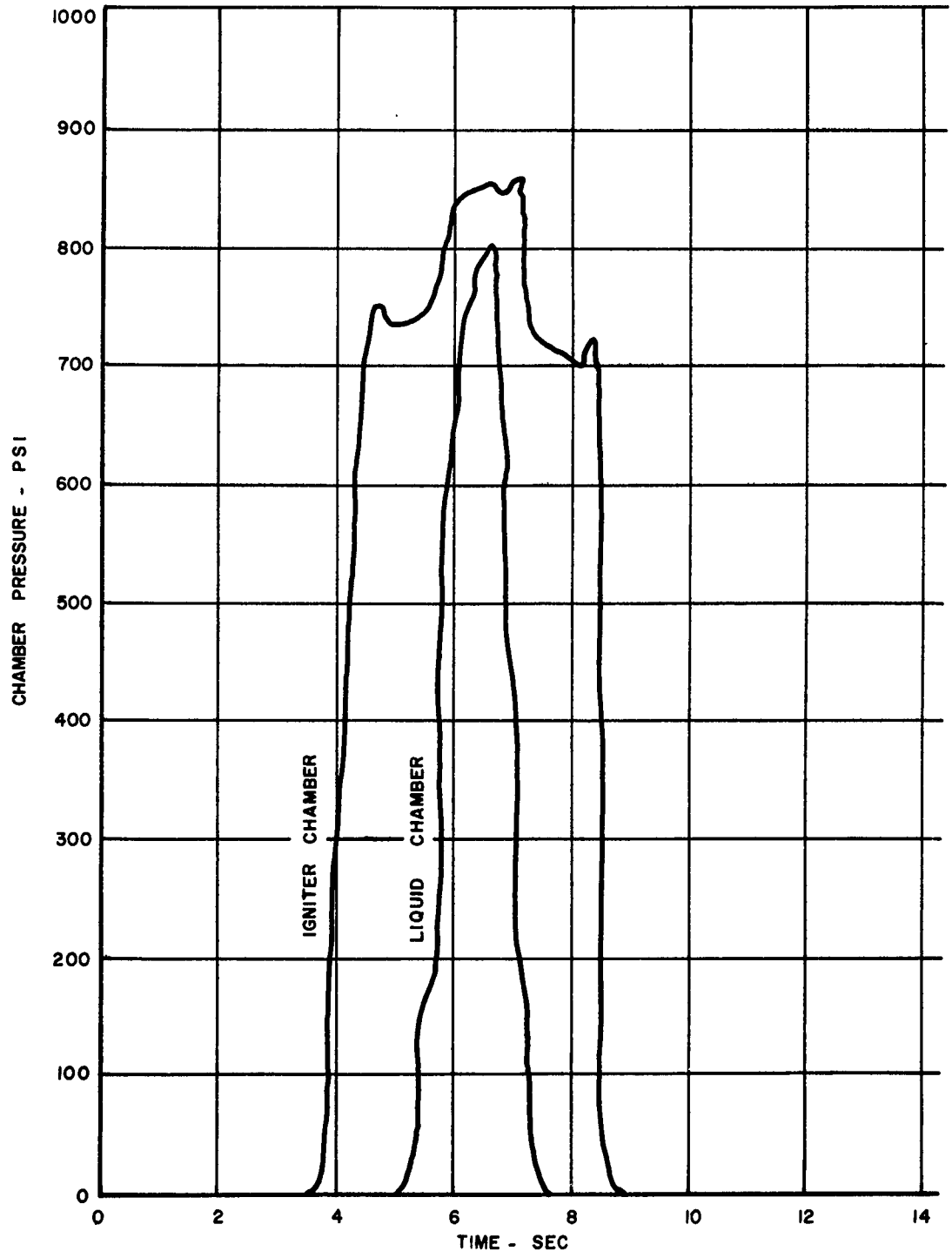


Figure 5. System Test Firing - 13 June 1962 (Run No. 17)

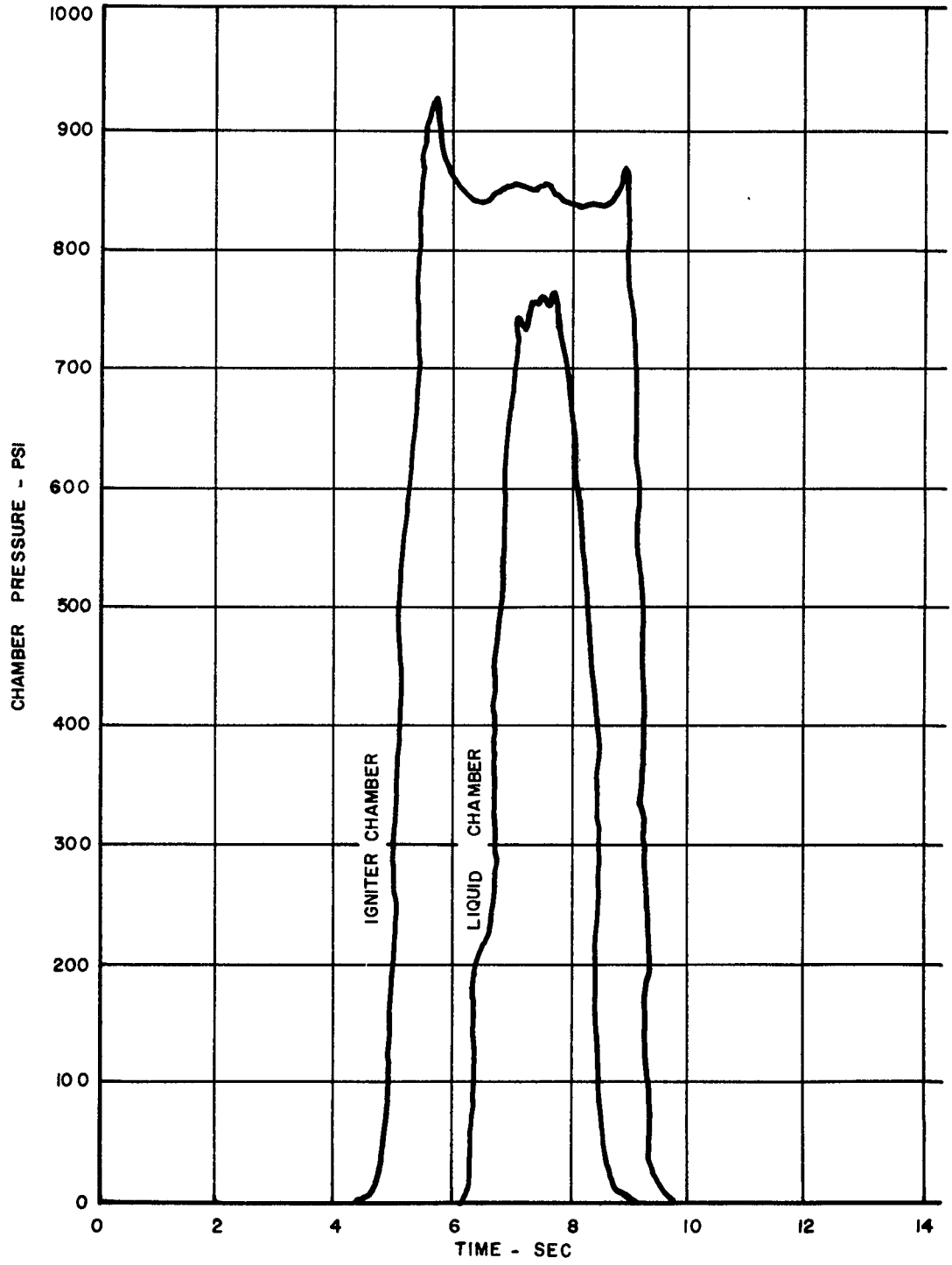


Figure 6. System Test Firing - 6 July 1962 (Run No. 24)

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Unclassified Report

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1. Pyrogen
2. Igniter
3. LO_2-LH_2 Rocket Igniter

I. AFSC Project 3059

II. P Moedt 1/Lt., USAF

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